

38 Imaging

38.1 Radiology methods for the generalist

X-rays are electromagnetic waves of 0.1-0.5Å (0.01-0.05nm); they are usually generated in vacuum tubes by passing a high voltage current to heat tungsten filaments. These can occasionally break and need replacing, or else if they overheat (>3380°C) give off tungsten vapour which is deposited on the inside of the vacuum tube, so reducing the output of X-rays. The heat generated by the X-rays must be dissipated, and most machines have a thermostat cut-off device.

The basic WHO radiological system (1.12) is the most appropriate for the district hospital. The machine consists of an X-ray tube, high tension cable, collimator and grid (to reduce the X-ray beam to the area of interest and improve the definition) and a cassette plate with its holder.

Wear lead body protection, and try to obtain a radio-activity dosimeter if you take many radiographs.

Take care to position your patient correctly, remove clothing (especially with buttons and objects in the pockets), ear-rings and piercings, make sure that braided hair is out of the way (*it can look like TB on a chest radiograph!*), and select the correct X-ray penetration (usually indicated on the machine). Check if a female patient might be pregnant (*a history alone may not be accurate: do a β-HSG test*): avoid X-ray exposure in this event.

Make sure the radiograph is correctly labelled (best with a marker on the cassette) as to left or right.

Carcinoma of the oesophagus may be so common that you will find a barium swallow, which is quite easy to do, particularly useful. A barium meal and enema are more difficult, but with reasonable practice you can learn quite a lot from them. Upper gastrointestinal endoscopy (13.2) and procto-sigmoidoscopy (26.1) will usually give you more information, if available. Cystoscopy (27.3) may give you the information you need, and is cheaper than contrast radiology. Information from an ultrasound may, however, make this superfluous. However, a urethrogram, by outlining the passage to the point of a stricture or fistula, is simple and helpful.

N.B. You can often demonstrate a bowel fistula by injecting dye rather more easily, avoiding the need for X-rays.

(a) Intravenous urogram (IVU)

INDICATIONS

N.B. Do an ultrasound first, if you can!

- (1) An obstructive uropathy, particularly a hydronephrosis or a ureteric stricture, especially in areas where schistosomiasis is endemic, provided renal function remains fairly good.
- (2) To see if a mass is renal.
- (3) To assess the function of the contralateral kidney, when you consider referring for nephrectomy.
- (4) Renal trauma.
- (5) Renal or ureteric stone (27.13).

CONTRAINDICATIONS

(1) If the blood [urea] >10mM, an IVU will probably fail because the contrast will not be excreted in adequate concentration to be visible.

It is certainly not worth doing if the blood [urea] is >17mM.

- (2) Renal failure.
- (3) Hepatic failure, which may be aggravated.
- (4) Cardiac failure; there is a risk of arrhythmia.
- (5) Dehydration.
- (6) Babies <2yrs old.
- (7) The first trimester of pregnancy.
- (8) Multiple myeloma.
- (9) Sickle cell disease.
- (10) Any previous reaction to contrast, or to iodine.

You can prepare an allergic patient by administering prednisolone 50mg orally 12 and 2h before the injection of contrast.

Be prepared for an anaphylactic reaction: have ready 0.5ml of adrenaline 1/1000 and promethazine 25mg IM.

PREPARATION. Restrict the patient to oral fluids and use a laxative to empty the bowel. Air will not spoil the film, but a mixture of air, fluid and faeces will. *Do not use an enema.* If the IVU is urgent, do it without preparation.

CONTRAST MEDIUM. Use 'Urografin' (Meglumine and sodium amidotrioyate) 60% or 'Conray (Iothalamate meglumine) 420'. These are hyperosmolar solutions.

FILMS. Use 18x24cm for the bladder; 24x30cm for the renal area; 30x40, 35x35, or 35x43cm for the whole abdomen.

UROLOGICAL RADIOGRAPHS

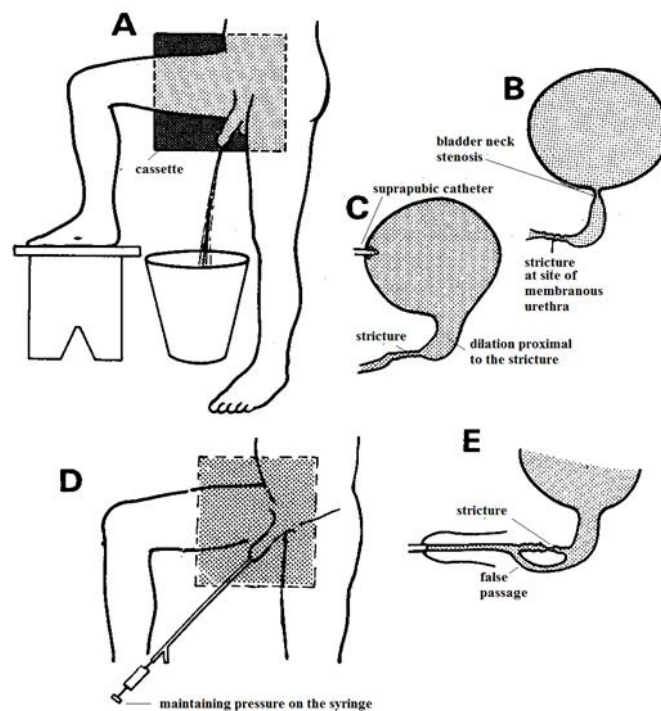


Fig. 38-1 UROLOGICAL FILMS.

A-C Micturating cystourethrogram. **D,E** Retrograde urethrogram. **A**, fill the bladder with contrast medium, and take a film whilst the patient is passing urine. **B,C**, 2 types of obstruction. **D**, inject contrast up the urethra from below (this shows an oblique view at 25°). **E**, demonstrating a false passage.

METHOD. The following method minimizes the number of plates needed. The views are all AP; 60mA at 68kV should be enough for a 60kg adult.

Lay the patient supine on the X-ray table. Take a preliminary view of the abdomen and pelvis on a 30x25cm plate, before infusing the contrast medium. Inject 40ml IV rapidly.

(1) At 3mins take a 25x30cm plate of the kidneys.

If the calyces are of obviously normal shape and size at 3mins (be quick: it will need 5mins in the developer, fixing and washing), you can omit the 20min film.

(2) At 20mins quickly take a 35x43cm plate to show the kidney, ureters and bladder.

(3) At 30mins ask the patient to empty the bladder, and then take a small plate to show the residual urine.

If the function of the kidneys is impaired, so that there is little excretion in the standard films, repeat them at 2h, and if necessary at 6h.

(b) Retrograde urethrogram (38-1D)

INDICATIONS

- (1) Urethral stricture, or leak.
- (2) Congenital anomalies.
- (3) Prostatic abscess.
- (4) Urinary inguino-scrotal fistulae.
- (5) False urethral passages.
- (6) Urethral rupture.

CONTRAINDICATION. Acute urinary infection.

CONTRAST MEDIUM. Use contrast medium such as 'Umbradil Viscous U', 45% diatrizoate (Hypaque), or Urografin 60%.

N.B. You can dilute these with an equal volume of water and still get good pictures.

CAUTION! Do not use barium, or an inorganic iodide.

METHOD. This is most often done in males. Using aseptic precautions, insert a Ch12 Foley catheter for only 2cm into the urethral orifice. Gently inflate the balloon with *only* 1-2ml of sterile water. The expanded balloon will now fix the catheter in the *fossa navicularis* (27-18). Fix a length of tubing to the catheter. You can now position the patient more easily, and be further from the radiation yourself when you inject the contrast medium. Check that there is no extravasation by injecting sterile water from a bladder syringe connected to the Foley catheter.

Then inject c.10ml of the medium and take an oblique film at 25° (with the patient lying on his side with the pelvis tilted to 45° and the upper hip out of line of the X-ray beam). Take the film maintaining mild pressure on the bladder syringe. If the bladder is reasonably filled, you can follow a retrograde urethrogram with a micturating cystourethrogram.

The membranous urethra is separated from the penile urethra by a line, which runs from the junction of the upper 1/3 and the lower 2/3 of the pubic ramus on one side, to a corresponding point on the other side.

A stricture shows as a significant narrowing in the urethra outlined by the contrast, almost invariably in the membranous urethra.

(c) Micturating cystourethrogram (MCU, 38-1A)

N.B. This shows up the proximal end of the stricture, and will also show bladder neck stenosis. The bladder must be filled with contrast medium to begin with. If you can pass a catheter through the urethra, you can fill it that way, but contrast may leak out when you remove the catheter. If a suprapubic catheter is *in situ*, use that to fill the bladder.

INDICATIONS

- (1) Urethral stricture.
- (2) Suspected abnormalities of the bladder neck.
- (3) The assessment of vesical diverticula.
- (4) Cysto-ureteric reflux.

CONTRAINDICATION. Acute urinary infection.

CONTRAST MEDIUM. Use either:

- (1) 40ml 60% 'Urografin' diluted in 400ml of saline.
 - (2) 250ml 30% 'Urografin', or
 - (3) 400ml 12.5% sodium iodide with 0.1% sodium metabisulphite.
- This is the cheapest.

The sodium iodide must be sufficiently pure; *small contaminants of fluoride in it can be nephrotoxic.*

METHOD. Empty the bladder through the catheter. Using an intravenous infusion set or a large syringe, fill the bladder again through the catheter with 300-400ml of contrast medium until there is a strong desire to pass urine. Clamp a suprapubic catheter or remove a urethral catheter. Take an erect oblique AP film at 80mA and 80kV with the patient standing to pass urine. Or take an oblique film at 25° in the lying position; there will be less blur due to movement. Use a cassette to hold the X-ray plate still.

(d) Contrast swallow (38-2)

INDICATIONS

N.B. Do an endoscopy first if you can.

Dysphagia due to:

- (1) Carcinoma of the oesophagus (30.5).
- (2) Post-corrosive or reflux strictures (30.3).
- (3) Achalasia (30.6).

CONTRAINDICATIONS

- (1) Impaired conscious level.
- (2) Dysphagia of neurological cause.
- (3) Tracheo-oesophageal fistula.
- (4) Suspicion of an oesophageal tear.

CONTRAST MEDIUM

- (1) Thin barium, gastrografin or Iodipamide (Endografin).
- (2) Barium sulphate; thicker than for a barium meal, yet not so thick as to aggravate an obstruction.

CAUTION! Check to make sure the patient does not have a complete dysphagia, which may cause aspiration. Do not use barium carbonate, which is highly poisonous.

METHOD. Stand the patient in front of the X-ray screen facing you. Ask him to fill the mouth with contrast medium, but not to swallow it until you ask him to. Use a closed feeding cup (which is less likely to spill in the dark), or a stiff 5mm plastic straw. The mixture of air and barium swallowed will produce an informative 'double contrast' film.

SOME CONTRAST SWALLOW RADIOGRAPHS

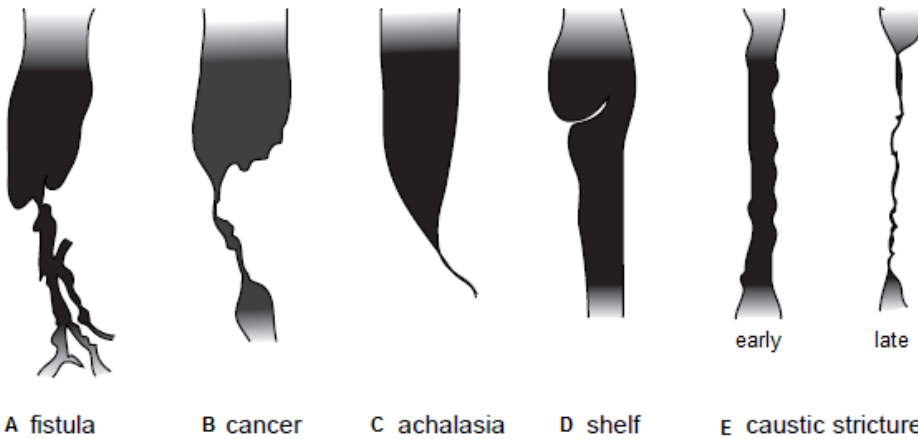


Fig. 38-2 SOME OESOPHAGEAL SWALLOW RADIOGRAPHS. A, malignant fistula into pleural cavity or bronchus. B, late oesophageal cancer. C, achalasia of the cardia. D, a shelf as in a short corrosive stricture or Plummer-Vinson syndrome. E, grades of long caustic stricture (early & late).

Adjust the X-ray machine to provide a narrow vertical aperture. Then ask the patient to swallow and take a film while he is swallowing the contrast. Then take a lateral film with the patient standing with his hands above his head. You should be able to see all but the upper end of the oesophagus quite easily. If necessary, take 2 oblique views, in addition.

(1) **Malignant strictures** (oesophageal carcinoma) cause a narrowing with an abrupt start and an irregular rounded shoulder; above it the oesophagus is usually dilated. The lumen through the tumour is irregular and is typically rat-tailed, and you can usually see the end of the stricture. You should be able to demonstrate 90% of carcinomas with simple screening. An ordinary PA film may show widening of the mediastinum. Be sure to use a long plate to get the whole oesophagus on to it, and *do not centre the X-ray tube on only one part of it*.

A mouthful of contrast medium and one large film will usually show an advanced tumour.

(2) **Late inflammatory benign strictures** due to reflux produce a stricture which is usually long and smooth.

(3) **Achalasia** (uncommon, 30.6) shows as a 'bird's beak' at the bottom end of a greatly dilated oesophagus. Take oblique films.

(e) Barium meal

INDICATIONS

N.B. Do an endoscopy first if you can.

- (1) Carcinoma of the stomach.
- (2) Gastric outlet obstruction.
- (3) An upper abdominal mass suspected of being gastric.

METHOD

Perform a barium swallow first with thin barium. Adjust the aperture of the X-ray beam to let you see the entire stomach. Ask the patient to stand facing you.

Then ask him to swallow thicker barium, enough to fill half the stomach. If you can, screen him in this position and in the left oblique position (he should look beyond your left shoulder), or use the right oblique position.

(1) STOMACH

Watch for peristalsis carefully. Does barium pass through normally all the way to the pylorus?

Suggesting carcinoma: an immobile area of stomach lining, persistently irregular surface, or consistent filling

defect make carcinoma very likely.

Suggesting a gastric ulcer: an ulcer, usually on the lesser curve, in the distal half of the stomach. Expose 1-3 plates, asking the patient to hold his breath as you do so.

N.B. Looking for a hiatus hernia is not very reliable with radiographs, and anyway does not always correlate with gastro-oesophageal reflux.

Suggesting a diaphragmatic hernia: a round volume of contrast in the thorax.

(2) DUODENUM

Note if there is a delay in the passage of barium through the pylorus: it should start passing at 1-5mins. Use a special attachment which will exclude all X-rays except those in a 10cm circle. Turn the patient to face obliquely to your right as far as is necessary for you to see the pylorus and duodenal loop. Expose plates as the barium passes. You may be able to recognize a deformed duodenal ampulla while you screen, but you will see scarring or a duodenal ulcer more easily on static films. With experience, you will recognize enlargement of the duodenal loop (as by carcinoma of the head of the pancreas).

Suggesting gastric outlet obstruction: pyloric delay keeping contrast in the stomach.

(f) Barium enema (38-3)

INDICATIONS

- (1) Suspected amoebic strictures.
- (2) Carcinoma of the large bowel.
- (3) A mass which might be colonic.
- (4) Inflammatory colitis.

CAUTION! Do not do a barium enema until you have performed both proctoscopy and sigmoidoscopy, which will often establish the diagnosis more easily and cheaply.

CONTRAINDICATIONS

- (1) Patulous anus.
- (2) Rectal biopsy immediately preceding the enema.

EQUIPMENT

An X-ray machine with a screen. A 2L douche can. A flatus tube, Ch30 rubber or plastic, 2m long. 2 large artery forceps. A Higginson's syringe (38-3). A grid on top of the X-ray plate.

METHOD

Prepare the patient with oral bowel preparation and a rectal washout (not merely an enema) within the previous 12h; maintain good oral hydration during this time, but withhold solids. Oral preparation is not necessary in children and a rectal washout alone is satisfactory.

CONTRAST MEDIUM. Use barium/air contrast with the equipment described (38-3).

N.B. Do not use oral bowel preparation on a patient with obstruction.

CAUTION! Manipulate the flatus tube with gloves. Have toilet paper and a bedpan ready: it may be required urgently!

CONTRAST COLONIC ENEMA

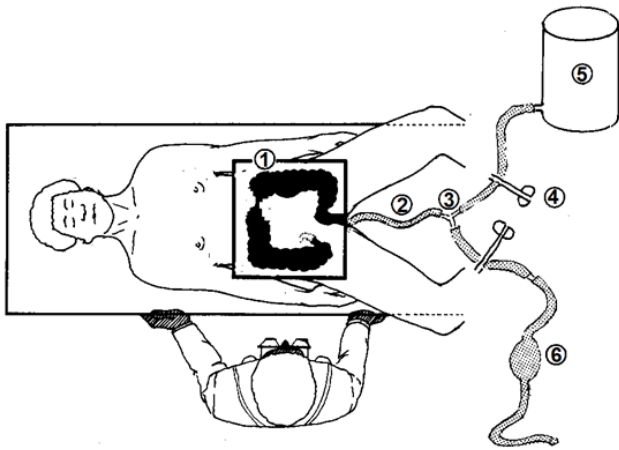


Fig. 38-3 ARRANGEMENTS FOR A RADIOLOGICAL ENEMA. You will probably be able to demonstrate the large bowel as far as the hepatic flexure without much difficulty; the ascending colon is more difficult. *Note that you should wear goggles and an apron.*

1, a radiographic grid and X-ray plate; these are usually in a cassette under the X-ray table. 2, Ch30 flatus tube. 3, a standard Y-connector. 4, artery clamps. 5, a 2L stainless steel douche can. 6, a Higginson's pump syringe. (The illustration shows a typical 'filling defect' suggesting a colonic cancer, 12.11).

Adapted from James Cairns & Rogers Mungalu.

Lay the patient supine on the X-ray table, and ask the patient to flex and abduct the hips. Cover the male gonads with a lead shroud. Lubricate the flatus tube well with lubricant, and push it through the anus, as far as it will go easily. Extend the legs on the table. Inject barium and air, as required, to show the large bowel up to the caecum. Inject a fair amount of barium first, and follow this by pumping air with the Higginson's syringe to move the barium proximally, clamping and releasing the tubes as necessary. Instil some barium, and then some air. You will probably be able to demonstrate the large bowel as far as the hepatic flexure without much difficulty; the ascending colon is more difficult. The limiting factor is the distension of the large bowel with barium and air, and the urge to defecate that this produces. If there is much discomfort, wait 2-3mins and try again with more barium and more air.

If possible, watch the movement of barium and air on screening, and expose plates of critical areas. Before defecation, which the patient is usually keen to do without delay, take a standard abdominal film. Expose another plate after defecation. The film of barium

left on the mucosa will often give the clearest picture. Finally, remove the flatus tube and allow bowel emptying into a bedpan.

(g) Carotid arteriogram (38-4)

INDICATIONS

- (1) Suspected extra- or sub-dural haematoma.
- (2) Intracerebral mass.
- (3) Suspected cerebral aneurysm in a patient with a subarachnoid haemorrhage.
- (4) Arteriovenous malformations.

CONTRAINDICATIONS

- (1) Bleeding disorder.
- (2) History of transient ischaemic attacks.
- (3) Previous allergy to contrast, or to iodine.

EQUIPMENT. An X-ray head table, preferably marked to line up the midline. 2-way connecting tubing. Quickly changeable cassette box.

METHOD. Place the patient supine with the head carefully placed AP in the midline position; it is useful to be able to strap the forehead in place. If the patient is restless, sedate him appropriately. Sterilize the skin of the neck on both sides and infiltrate 2ml 1% lidocaine under the skin over the pulsations of the carotid artery. *Do not put in too much*, otherwise palpation of the artery will be difficult. If you have an ultrasound, this is very useful to localize the artery.

CONTRAST MEDIUM. Prepare 20ml iopamidol (Isovue 200 or 370) or iotalamic acid 45% (Conray 280) in a sterile syringe. These contain 200, 370 or 280g iodine/L respectively. *Do not use stronger solutions* as they may cause vasospasm. Make sure the radiographer is ready.

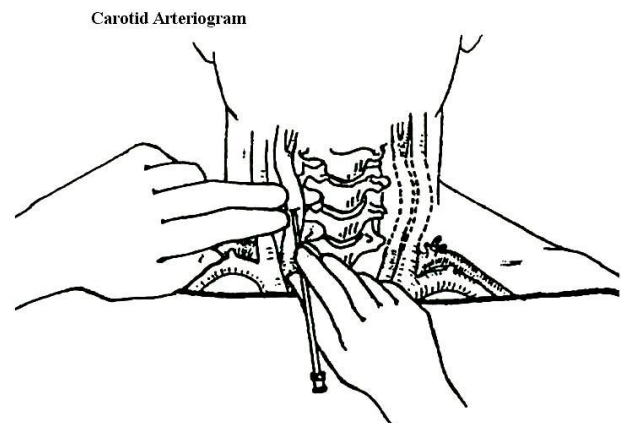


Fig. 38-4 TECHNIQUE OF CAROTID ARTERIOGRAPHY.

Direct puncture of the carotid artery.

After Rosenfeld JV, Watters DAK. Neurosurgery in the Tropics. Macmillan 2000 p.41 Fig 2.16 with kind permission.

Puncture the carotid artery directly from the front with a 19G 5-8cm long lumbar puncture needle (38-4), and secure it. This should be flushed with saline and have a plastic connection, already attached, to which you can fit the syringe with the contrast medium. Inject a 10ml bolus of contrast and take films whilst you are injecting, and then every 2secs after you have put in 5ml. If you cannot do this, inject all the contrast quickly and take one film as the last drops of the contrast injection are going in. (*You must shout to the radiographer when to shoot!*)

Then inject another 10ml contrast and get 2 more films for the capillary and venous phases after 3 & 6secs.

Being careful not to displace the needle, turn the patient's head on its opposite side, and repeat the injection of 10ml contrast to get films in the lateral position.

Finally, when you are satisfied with the quality of the films, remove the needle and press on the puncture site for a full 1min, *without occluding the flow in the carotid artery.*

Look for displacement of the anterior cerebral artery from the midline: this is why accurate alignment of the head is so important. Look for an area of the brain on its edge that seems to receive no blood supply. Look for a 'tumour blush' or vessels displaced around a lesion. Look for a 'blow-out' of an aneurysm.

(h) Myelogram

INDICATIONS

- (1) Progressive neurological limb deficit suggestive of an intraspinal lesion, *viz.* para- or tetra-paresis.
- (2) Acute spinal cord compression.
- (3) Sciatica not improving with conservative treatment.

CONTRAINDICATIONS

- (1) Raised intracranial pressure.
- (2) Septic lesions on the back.
- (3) Allergy to iodine.

METHOD. Place the patient in the lateral position with the lumbar spine well flexed but not crooked, with a pillow between the knees. Find the CSF as for a lumbar puncture at the L4-5 level, and inject 20ml iopamidol. For lumbar views, take AP and lateral films soon after the injection. For thoracic views, tilt the table, so that contrast runs up the spinal canal, and then take more AP and lateral films.

(i) Sialogram (17.5)

INDICATIONS. Stricture or stone in the salivary duct.

CONTRAINDICATION. Active sialadenitis.

METHOD. Anaesthetize the buccal mucosa with lidocaine spray. Find the duct orifice: the parotid (Stensen's) duct opens opposite the 2nd upper molar tooth (31-1) on the buccal side, and the submandibular (Wharton's) duct opens at the side of the frenulum of the tongue. Pass a probe to dilate the orifice, and inject a little lidocaine; then inject 0.5ml contrast and immediately take the films of the mouth.

(j) Sinogram and fistulogram

INDICATIONS. To demonstrate a sinus or fistula.

METHOD

If you suspect a fistula to extend from skin to the large bowel, use bowel preparation beforehand.

Make sure you plug the sinus or fistula, so that when you inject contrast it does not spill back out: you can use stoma paste for this, or pass a small Foley catheter and inflate the balloon to secure it in place. Take films in AP, oblique and lateral positions.

(k) Operative cholangiogram (15.8)

INDICATIONS

If during cholecystectomy you feel a stone or if you have lost a stone in the common bile duct, or there has been a history of jaundice, or the common bile duct is dilated.

METHOD

When you have clearly identified and exposed the cystic duct, attach a 20ml syringe with saline to a fine plastic cannula and flush out air bubbles, and pass the cannula into the cystic duct by making a small opening into it. Secure the cannula in place with a fine suture, after making sure the saline passes freely into the duodenum. Remove instruments and swabs from the operative field, and cover the wound with a sterile towel. Tilt the table 10-15° to the left, and get the X-ray machine properly positioned. Withdraw bile into the cannula to make sure it has not slipped out of the duct, and then inject 4ml of 25% warm sodium diatrizoate (Hypaque) contrast medium and take a picture. Repeat this with 8ml for a second exposure. Gallstones appear as filling defects, so it is vital that air bubbles are removed as these may be confused with gallstones!

Whilst waiting for the films, *do not proceed with removing the gallbladder*, because you may want to do a cholecystojejunostomy (15.9) if you cannot remove a stone impacted in the distal common bile duct.

If the films show no flow into the duodenum and there is no sign of a filling defect, try flushing with warm saline and adding 20mg hyoscine IV (an antispasmodic), and repeating the test with 12.5% sodium diatrizoate. (You can use air, however, if all you are testing for is free flow into the duodenum.)

(l) Hysterosalpingogram (HSG: 19.3)

CONTRAINDICATION

Pregnancy.

CAUTION!

- (1) Before you start, do a pelvic examination (or ultrasound scan) to exclude pregnancy and active pelvic infection, and
- (2) Do a β -HSG test within 10 days of the 1st day of a woman's menstrual period, and not in the premenstrual or active menstrual phases of the cycle.

PREPARATION. Administer prophylactic tetracycline and metronidazole beforehand. Use a special cannula such as the Leech-Wilkinson screw-in type (the Miller cannula causes less trauma to the cervix, but does not make such a good seal with it) or a very small size Foley catheter but this needs a special syringe to provide a proper seal.

CONTRAST MEDIUM. Prepare a suitable 20ml syringe filled with a water-soluble, such as 'Urografin', or other hyperosmolar contrast medium, which may help open the tubes.

METHOD. If possible, screen the patient during injection of the contrast medium. Lie her supine on the X-ray table with her hips and knees flexed, and the plate under her pelvis. A tube-plate distance of 1m is satisfactory.

Insert Cusco's speculum (19-1) and clean the cervix with cetrimide or povidone-iodine. Hold the cervix gently with a single-toothed tenaculum, lightly closed to the first ratchet; this should cause little discomfort.

Expel all air from the syringe and cannula, inject 20ml contrast medium firmly through the cervix, and take a film. If there is a cornual obstruction, 20ml will not pass through the Fallopian tubes out of the uterine cavity. If possible, take a second film 3h later. The contrast should have spread into the peritoneal cavity. If it remains loculated, this suggests adhesions and impaired fertility.

38.2 Ultrasound methods for the generalist

Unlike radiographic images, sonographic pictures are not generated by radiation but by sound waves of frequency 1-13MHz. The lower the frequency, the shorter the wavelength and so the greater the penetration.

This technique is therefore *non-invasive*. Sound waves are sent into the human body and are reflected in it. These reflections take place at the interface of different tissues/structures due to various sound transmission abilities. Therefore the brightness of an organ on the display is not related to its physical density but to its echogenicity. This depends on the difference of acoustic impedance, *i.e.* (density) x (speed of ultrasound waves passing through), between the tissues.

Consequently, fluids like blood, urine and pleural fluid appear black (anechoic) as there are no interfaces where sound could be reflected. Unfortunately, pulmonary/intestinal air and bone reflect almost all the sound waves, obscuring any image from what lies behind the air or bone. However, you can usually get round this problem (except in the adult head).

Ultrasound is cheap and quick and can help you in a whole set of potentially difficult or dangerous situations. But the quality and reliability depend, more than in other techniques of examination, on the experience and knowledge of the examiner, and the quality of the machine. If there is a doctor experienced in ultrasound around, ask him to teach you; it's worthwhile to learn this technique.

You will find a large variety of ultrasound scanners available on the market. Therefore, if you want to buy one, make sure you order an instrument of a specification that will allow you to get useful data from it. It may be better to have no scanner than to have one that gives poor-quality images which can lead to wrong diagnoses.

Use sector (convex) probes for the abdomen, and a round probe for cardiological examinations. Use linear (flat) probes for scanning superficial structures, including the breast and thyroid. A combined linear and sector probe can cover all areas; convex probes are also useful in the majority of body areas. *Remember to orientate the probe in your hand correctly so the image on the screen corresponds with the patient's position and is not back to front, or upside down! (Touch the side of the probe where the marker is situated to see on the screen to which side this corresponds.)*

N.B. Increase in gain brightens the image; increase in depth magnifies the image.

A good compromise frequency is 3-5MHz, while 5MHz is useful for scanning children and superficial organs. The WHO manual of diagnostic ultrasound (Vols. 1 & 2) produces good guidance on this:

The specifications for a general purpose ultrasound scanner are as follows (*N.B. check technical terms in guidebooks!*). It should have:

1. A transducer which is curvilinear (convex), or a combination of linear and sector.
2. A transducer with a central frequency of 3-5MHz, with accurate focusing. If you can afford it, an optional transducer of 5MHz is useful, but should not replace the 3-5MHz one.
3. A sector angle of $\geq 40^\circ$ and a linear array 5-8cm long.
4. Simple control buttons easy to use. Overall sensitivity (gain or transmitter power) and time-gain-compensation should be an integral part of the circuit. These vary the clarity of the image from a pre-set level. However, this is not essential because if the time-gain-compensation is at the correct level for obstetrics, with a pre-set alternative for the upper abdomen, you can still examine >80% patients satisfactorily.
5. A frame rate 15-30Hz for the linear probe and at least 5-10Hz for the sector probe.
6. A frame freeze density 512x512x4 bits (to provide 16 grey levels).
7. At least one pair of electronic omni-directional calipers with quantitative readout, to measure lengths on the screen.
8. Software to add patient identification data to the screen and the final record.
9. Software to obtain a permanent record (memory) of the scan.
10. A video monitor screen measuring at least 10x10cm², preferably larger.
11. A reasonable weight, so that an average adult can move it over at least 100m; if on wheels, these must be suitable for rough irregular surfaces, but one that you can carry and even put in a vehicle is better. However, the more your machine is mobile, the more easily it may be stolen!
12. Protection for the local climate, and against dust, damp, and extremes of temperature. It should be possible to use the scanner continuously within a temperature range of 10-40°C and 90% relative humidity.
13. Connection to the local power supply and be compatible with the voltage, frequency and stability of the local current. It should be able to stabilize a voltage variation of $\pm 10\%$. If there is greater fluctuation in the local current supply (and you must test this before you buy), you need an additional voltage stabilizer.
14. A local service provider for the equipment.
15. Instructions easy to understand, in a language staff can read!

N.B. Many ultrasound scanners incorporate biometric tables (*e.g.* foetal maturity measurements) in the microprocessor memory. These are useful, but check that the measurements you make are done in exactly the same way as was used to provide the tables. Biometric tables may not be universally applicable and should be adjusted for local conditions.

N.B. You do not need a printer! You can use petroleum jelly for the transducer if special jelly is too expensive.

(a) Artefacts

Before you start to have a closer look at ultrasound applications, note the simple phenomena which appear on an image due to the physical characteristics of sound. Find out what is really artefact and what is not. Some artefacts are useful, *e.g.* in diagnosing a pneumothorax (36.1).

(1) Distal acoustic enhancement

This is the relative enhancement of the signal of a wave beyond a fluid-filled cavity compared with the signal had it crossed through surrounding tissue. While passing the fluid, the sound is not much weakened. This causes the tissue beyond the fluid to appear brighter. Use this effect to distinguish between cystic structures and tissue!

(2) Acoustic shadowing

Structures which reflect sound very strongly like bones, stones and pulmonary/intestinal air prevent sound waves passing through. This results in blackish bands behind such structures which make evaluation there impossible.

Use this effect in atherosclerotic plaques and to reveal stones in the gallbladder, kidney and bladder! If the transducer has poor contact with the skin of the patient, there will be black bands through your image, too. But these ones start right at the skin level and they will disappear upon using more air-displacing gel.

ABDOMINAL ULTRASOUND TECHNIQUE

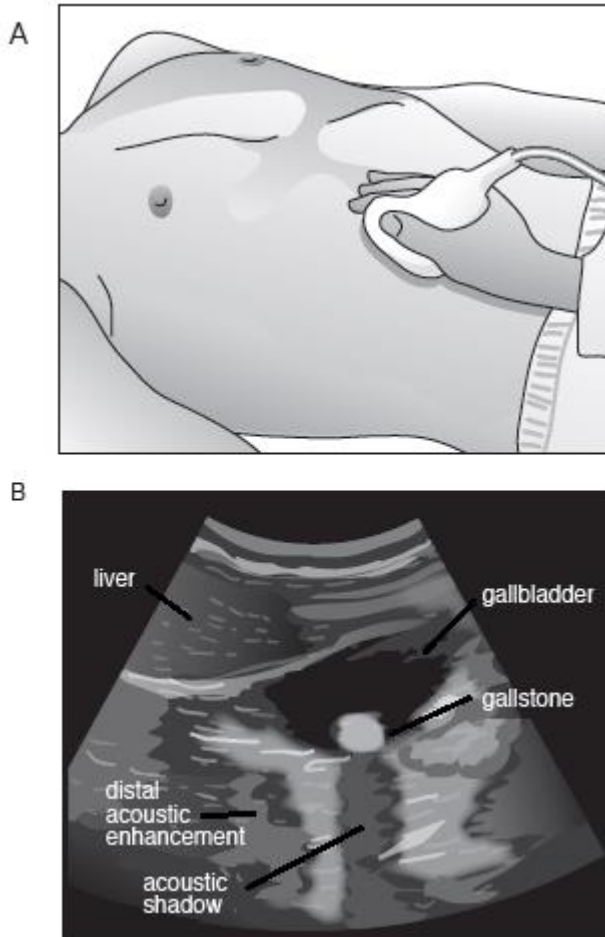


Fig. 38-5 TECHNIQUE OF ABDOMINAL ULTRASOUND. A, position of the transducer. B, ultrasound image of a stone in the gallbladder.

After *Sonographiebilder.de/II, Medizin/Albertinen-KH Hamburg.*

(3) Section thickness

As the sound bundle that is emitted by the transducer has a (very small) thickness, sometimes the wall of a cystic structure appears thickened and fuzzy. Carefully distinguish this from layered material like blood clots or small concretions which change their localization after turning the patient around!

(b) Liver

APPROACH. Although the liver is easy to find, it is a challenge to examine it completely, not only for you but also for your patient who might get exhausted in holding his breath. Try to give your patient continuous breathing instructions and don't forget to allow him to breathe out after holding his breath. Ask for a deep inspiration and apply the transducer a little bit to the right side in the epigastric angle.

You should now comfortably see the dark IVC which is used to separate the left from the right liver lobe in ultrasound; the hepatic veins lead into the IVC, which is normally 13-15mm in diameter.

METHOD. Expect a healthy liver and kidney to have a similar echogenicity. A diffusely increased brightness of the liver is typical of a fatty liver, whereas an apparently reduced brightness is in most cases due to an increased brightness of the kidney (38-6). Sometimes you find a focally increased deposit of fat within the liver. These fatty infiltrations can look quite solid but are always sharply demarcated and never displace adjacent veins or bulge hepatic borders.

ULTRASOUND SCAN OF LIVER & KIDNEY

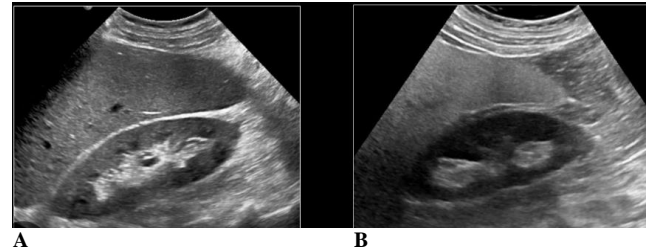


Fig. 38-6 Comparative echogenicity of liver and kidney. A, the two have similar density. B, the fatty or cirrhotic liver is hyperechoic. After Owen JW, *Radiology Education.*

In general, you don't measure the size of the liver but instead evaluate the inferior marginal angle of the right hepatic lobe which should be $<45^\circ$. The margin will appear rounded if the liver is enlarged. Throughout the parenchyma of the liver you will find porto-venous branches and hepatic veins. The former are always surrounded by a bright rim representing accompanying biliary ducts and peri-portal connective tissue, whereas the latter lack such a sign.

You can divide focal lesions into hyperechoic (brighter than the parenchyma) and hypoechoic lesions. Common findings in the liver are cysts (38-7A). Usually you don't need to be worried if the cyst appears anechoic and fulfils the cyst criteria (see below). These cysts are benign and require no further diagnosis. If a cyst is not anechoic anymore but displays internal echoes, you need to think of intracystic haemorrhage or of a parasitic hepatic cyst with septation (38-7B).

A common infection is due to *Echinococcus granulosus* (15.12), in which you will find one or several cystic structures with intraluminal echoes or solid parts (38-7C). The less frequent but more dangerous echinococcal disease (*Echinococcus multilocularis*) will appear as a mixed solid/cystic lightly calcified structure. Although it is difficult to differentiate such lesions from abscesses, hepatocellular carcinoma or metastases, *beware of aspiration* as there is a high risk of rupturing the cyst and seeding the parasite into the abdominal cavity.

ULTRASOUND SCAN OF LIVER CYSTS

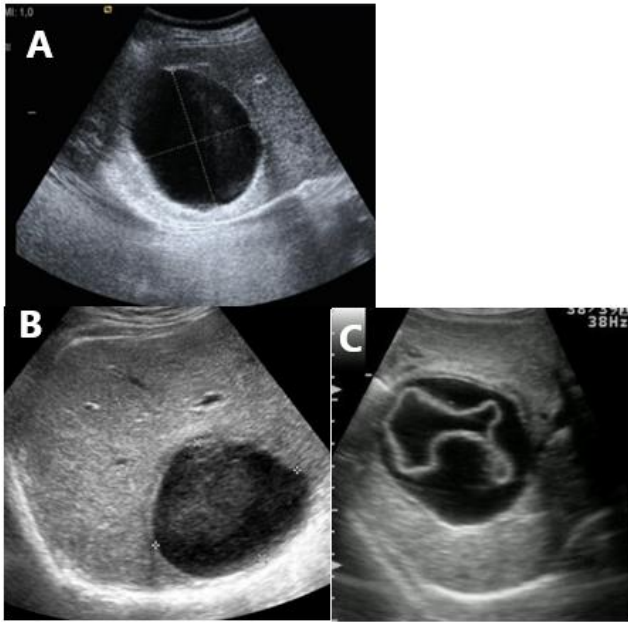


Fig. 38-7 Different liver cysts. A, a simple cyst (which may still be a hydatid). B, haemorrhage into a cyst. C, floating membrane inside a hydatid cyst.

After Davarci I, Tuzcu K, et al. *W Indian Med J* 2014;63(5):545-7 (A), Peer S. *Radiopedia.org* (B), *Sonographiebilder.de, Medizin/Albertinen-KH Hamburg* (C).

While you scan the parenchyma of the liver, pay attention to any kind of focal lesions which appear and disappear suddenly. Look for micro-abscesses suggestive of TB.

Although metastases in the liver present with a wide variety of echogenicity, a very typical sonographic sign is a dark narrow rim around the lesion which is called a 'halo'. Especially in fast-growing metastases, you can sometimes find a cystic hypoechoic centre caused by central necrosis. If a focal lesion has the same brightness as the liver parenchyma, you may only detect it due to space-occupying effects.

Look out for vessels which bend suddenly, bulging of the liver borders or jaundice in your patient because of compression of the biliary ducts. Focal lesions which present brighter compared with liver tissue can be harmless hepatic haemangiomas. They vary in size but are homogeneously hyperechoic, have a sharp but possibly irregular demarcation and typically display a bright narrow rim. Larger haemangiomas in which you also might find a dorsal acoustic enhancement sometimes become heterogeneous and are then difficult to differentiate from tumours. If your patient has a fatty liver, keep in mind that haemangiomas exceptionally are silhouetted hypoechoic against the very bright liver tissue.

Look for lymph nodes in the periportal area: these are very suggestive of TB.

(c) Gallbladder

To avoid acoustic shadowing while looking at the gallbladder:

- (1) Use appropriate pressure for your abdominal scan. This will push intestinal air out of the field of view. Your view of posteriorly located organs will not be disturbed by acoustic shadowing.
- (2) Use adequate breathing instructions. In inspiration the stomach and gas-containing bowel loops are displaced inferiorly and your view will not be disturbed by acoustic shadowing.

APPROACH. Apply the transducer in a sagittal orientation along the right mid-clavicular line just below the ribs (35-5A). Do your examination while the patient takes a deep breath and holds it. You will find the gallbladder as an anechoic structure near to the abdominal wall (38-5B). If you fail to see it, check that it hasn't already been removed, and place the patient in the lateral decubitus position. Try to get a true longitudinal view by rotating the probe on its axis: you will then see the gallbladder as an 'exclamation mark' on its side, with the right portal vein as the dot. If this fails, try with the patient in the knee-elbow position (12-5). Alternatively, especially in obese patients, view the gall bladder through the gap between the 9th and 10th ribs on the right anterolateral thoracic cage.

METHOD. Perform the examination before food. After food, the contracted gallbladder will not give you a good idea of oedematous wall thickening, polyps or stones and tumours (which are actually extremely rare).

Be sure to scan the gallbladder completely in 2 planes. Pay attention to luminal structures within the gallbladder. Stones usually generate acoustic shadowing, but tumours do not. If the stones are <4mm diameter, they may not give a shadow. Most often they lie in the most dependent part of the gallbladder and move about when the patient's position changes, unless they are impacted together and fill the gallbladder completely (38-8).

Peri-vesicular fluid will appear as a black fringe around the gallbladder as a sign of inflammation, perforation or ascites. The gallbladder wall is thickened (>2mm) in both acute and chronic cholecystitis: if >5mm it is definitely pathological.

ULTRASOUND SCAN OF CHOLECYSTITIS

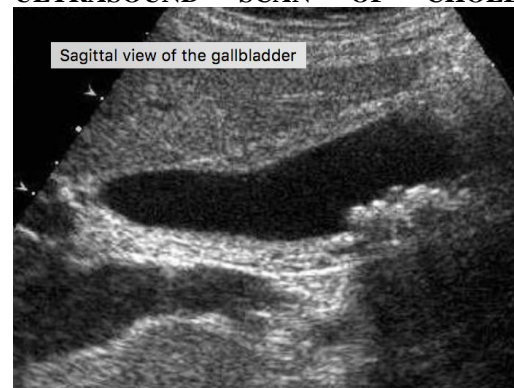


Fig. 38-8 Cholecystitis: many stones giving an echo, and a thickened gallbladder wall.

After Shah C, Johnson PT. *123sonography.com*

If you press directly with the probe on the fundus of the gallbladder and this causes acute pain, it is a true 'Murphy's sign' and a very reliable sign of acute cholecystitis.

Make sure you are not causing pain by pressing on the ribs!
It is crucial to recognize any air in the gallbladder due to a colonic fistula or to infection with gas-producing bacteria, as this is associated with a high risk of perforation. Cholecystitis usually occurs with gallstones present, but they may be absent especially in HIV disease.

If you suspect cholestatic jaundice, ultrasound can help you determine the level of obstruction. Measure the maximum diameter of the gallbladder, scan the common bile duct (best in the transverse view) which you will see as 2 bright lines anterior to the portal vein, and evaluate the small intra-hepatic bile ducts. Usually the intra-hepatic bile ducts are not visible but you will find them next to portal veins if they are dilated. If you find no dilation in either intra-hepatic or extra-hepatic bile ducts, jaundice is unlikely to be due to cholestasis, but from liver disease.

ULTRASOUND SCAN OF DILATED BILE DUCTS



Fig. 38-9 Dilated bile ducts have a 'tramway' appearance. Here many ducts are dilated from distal obstruction.

After Atlas of Ultrasound 2023 Erlangen Cookie-Richtlinien-EU.

You may spot worms or flukes moving in the bile ducts.

(d) Pancreas

APPROACH. Apply the transducer in a sagittal orientation to the right of the midline, tilt the head infero-laterally, and press hard. The pancreas is a relatively ill-defined structure superior to the aorta, IVC, superior mesenteric artery and vein.

METHOD. Adjust the position of the probe till you get an optimal view of the pancreatic tissue. This should be homogeneous, but if not, and if it is brighter and has fluid around it, or a visibly dilated pancreatic duct within it, these are signs of pancreatitis. If you see ≥ 5 dark structures in the area of the pancreas, one of these lesions is likely to be a pathological lymph node or a cyst: check for distal acoustic enhancement to confirm the presence of fluid in a cyst.

(e) Aorta and inferior vena cava (IVC): Retroperitoneum

APPROACH. To scan the superior retroperitoneum, apply the transducer in the epigastric angle, along the right of the *linea alba*.

It is helpful to ask your patient to take and hold a deep breath. With this manoeuvre the liver will move caudally and replace disturbing air-filled intestines.

After you have examined the superior part of the retroperitoneum, move the transducer caudally and do the same for the inferior retroperitoneum.

METHOD. As there are many things to pay attention to, try to stick to a concept. *Don't rush!* Your aim is not only to evaluate the aorta and the IVC for an aneurysm, a thrombosis or dilation but also to scan for lymph nodes. Firstly tilt the transducer probe to the patient's right side to scan the aorta which you will find dorsal to the liver. Does the wall of the aorta look smooth or do you find any evidence of atherosclerosis? Are there any localized dilations of the vascular lumen?

If there is a suspicious aneurysmal dilation, measure its diameter as the risk for rupture increases with size. Look out for intraluminal clots or a 'double' arterial wall, suggesting a dissection. These both appear less anechoic than the vessel itself because they might not only cut off the arterial supply to the spinal cord or to the kidneys but also increase the risk for rupture, too (38-10).

Then tilt the transducer probe to the left side to visualize the IVC and its continuation into the right atrium. In right heart failure you will find a dilation of the IVC as well as a loss of its typical 'double' pulsation. The normal IVC is smaller than the aorta. If you suspect right heart failure, scan also for pleural effusions and dilated hepatic veins. When you scan a vein, compress it from time to time. As long as a vein is compressible, there is almost certainly no thrombosis. Although this is a simple method, it is important as only a fresh thrombosis appears bright on your image: therefore you might overlook an older one if you don't compress the vein repeatedly.

ULTRASOUND SCAN OF AN AORTIC ANEURYSM

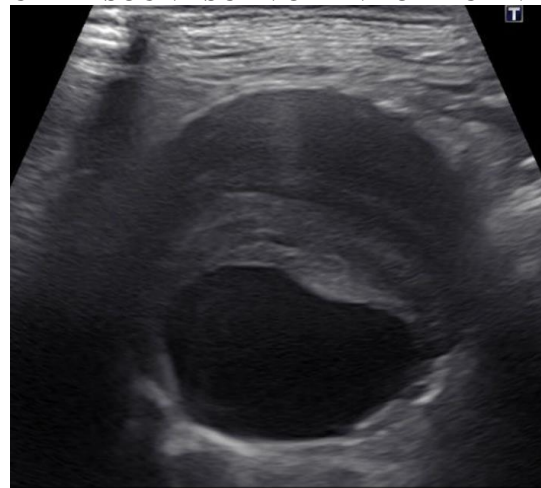


Fig. 38-10 Distended aorta with intramural atheroma.

After Atlas of Ultrasound 2023 Erlangen Cookie-Richtlinien-EU.

After your examination of the upper retroperitoneum, move the transducer caudally and do the same for the lower retroperitoneum. At some point you will not be able anymore to follow the aorta/IVC as it splits up into the external and internal iliac artery/vein.

If you suspect a deep vein thrombosis and you would like to scan further, change to a linear array transducer to examine the limbs.

(f) Kidney

APPROACH. The right kidney is much easier to examine than the left because you can use the liver as a window to scan through. Place the transducer in the mid-axillary line and ask the patient to breathe in deeply. Move the transducer slowly from the costal margin towards the iliac crest till you find the kidney, which is behind and inferior to the liver. Then rotate the transducer on its vertical axis so you see the whole length of the kidney, which lies obliquely. The left kidney can be difficult to visualize due to interfering ribs and intestinal air, so place the transducer in the posterior axillary line. If you have difficulty seeing the kidney, try placing the transducer head perpendicular to the intercostal spaces superior to the costal margin. *Try to avoid turning the patient to the side:* the kidney will move away from the abdominal wall and the image will probably worsen.

N.B. A kidney-shaped structure not in the correct position is likely to be an intussusception! This makes a doughnut-like image in the transverse view.

METHOD. A typical longitudinal section will be most useful for your evaluation of the parenchyma, but it is good to do a scan in both longitudinal and transverse views. The medullary pyramids are displayed like a row of black (hypoechoic) holes between the parenchyma and the central collecting system (brighter due to its hyperechogenicity). It might be difficult to differentiate vessels, cysts and medullary pyramids especially if scanning conditions are poor.

Cysts are a common finding especially in the elderly and you usually should not be worried about them. Be suspicious if a cystic structure is combined with calcifications (it might be renal tuberculosis) or if the cyst has non-homogeneous solid parts which might represent a malignancy. Normally the parenchyma of the kidney looks slightly darker than the liver; it becomes brighter (diffusely increased echogenicity) in all types of renal damage: it is a sensitive but non-specific sign.

However, in normal children, the kidney is usually slightly brighter than the liver. If you are thinking of nephrotic syndrome, search for pleural effusions and ascites. Measure the size of both kidneys and compare them. With age the parenchymal rim decreases physiologically but it might also be a consequence of several inflammatory episodes or chronic urinary obstruction. Renal disease usually causes the kidney to shrink <9cm in length.

If you are thinking of urinary obstruction, scan carefully for renal pelvic stones (you might only detect the shadows), for tumours in the uterus or the urinary bladder and an enlarged prostate. You cannot easily see strictures of the ureter.

In urinary obstruction, distinguish 4 distinct degrees:

- (1) I° : distension of the renal pelvis
- (2) II°: distension of the infundibula and calyces (38-11A)
- (3) III°: additional pressure atrophy of the parenchyma
- (4) IV°: virtual disappearance of the parenchyma (38-11B).

You might have a patient who has cysts and distended calyces. To differentiate between these conditions, scan in 2 planes and look for communication between the cystic structures. You will not find any if it is a simple cyst.

Cysts are typically in the cortex or periphery, and are smooth-walled. Hydronephrosis will communicate with a dilated renal pelvis; if it is due to an enlarged prostate or pregnancy, it will resolve after emptying the bladder. Classically in advanced hydronephrosis the appearance resembles dark branches like the fingers of a hand.

You may find a stone casting a shadow like a gallstone (38-11C) but they are more difficult to spot.

ULTRASOUND SCANS OF KIDNEYS

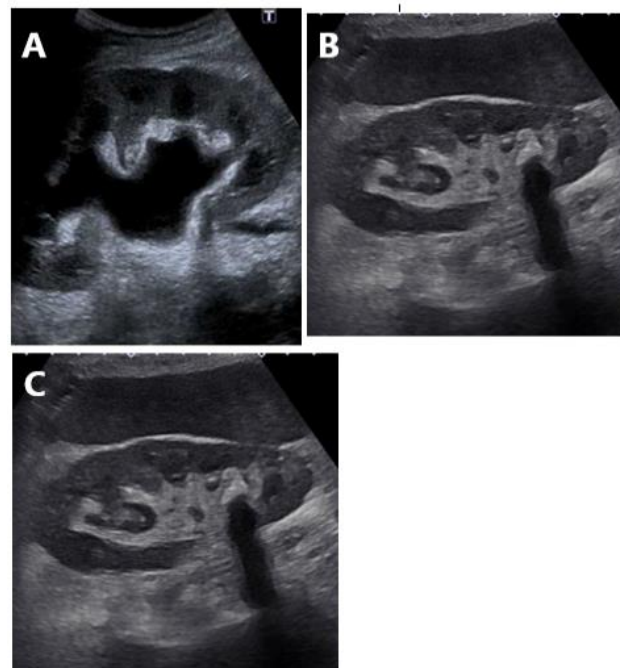


Fig. 38-11 Pathological kidneys showing: A, grade II, and B, grade IV obstructive nephropathy. C, a renal stone giving a shadow.

After Atlas of Ultrasound 2023 Erlangen Cookie-Richtlinien-EU.

(g) Spleen

APPROACH. Place the probe in the sagittal plane in the left posterior axillary line, and locate the spleen in front of the left kidney. It should be smaller (c.8cm) and brighter than the kidney and if it is larger, measure its size. Then look for a dilated portal vein. Look for micro-abscesses suggestive of TB.

(h) Retroperitoneal lymph nodes

APPROACH. Have your patient lying supine. It is best to perform this step right after you have done the scan of aorta and IVC.

METHOD. After you have evaluated the aorta and the IVC, direct your attention to potentially enlarged lymph nodes. Rock the transducer probe further to the left side until the IVC has vanished completely and perform a slow but steady movement with the probe back to the right side across and beyond the aorta.

Evaluate the space anterior and posterior to both vessels as well as the aortocaval space for ovoid space-occupying lesions.

Usually pathological lymph nodes are darker (hypoechoic) but there is no general rule and particularly lymph nodes which are enlarged due to metastasis of solid tumours have a very similar brightness as their surrounding tissue.

If the diameter of a lymph node is >1cm, if it is round and not oval, and if there is a group of suspicious lymph nodes, you should consider malignancy. Keep in mind that there are some structures which you can easily mistake for enlarged lymph nodes. Vessels can be differentiated easily if you perform a scan in two planes and tilt the transducer probe continuously: lymph nodes will appear and disappear while vessels can be tracked and join other vessels.

Sometimes bowel loops with content might look like a group of lymph nodes. It may help to apply rapid pressure impulses with the transducer to trigger peristalsis. It's especially important to keep anatomy in mind when scanning the superior retroperitoneum, as this is an area where you likely do find enlarged lymph nodes. Therefore be careful not to mistake either muscular extensions of the diaphragm, the oesophagus or the left renal vein for enlarged lymph nodes. Some lymph nodes are only detectable because they compress adjacent vessels, change their course or increase the distance between two structures, e.g. the retro-aortic distance should be <5mm.

If you have found any suspicious lymph nodes, try to describe in as much detail as possible what you have seen: e.g. how many nodes, what size, where exactly, any sign for abscess formation (anechoic centre). Using your knowledge of the lymphatic pathways, try to deduce where the site of the primary tumour might be. For example, in young men para-aortic nodes might suggest a testicular tumour. Additionally scan for hepatomegaly or splenomegaly.

Sonography is an appropriate technique to find suspicious lymph nodes but keep in mind that in a vast majority of your patients, these changes are due to inflammation and not to malignancy!

Make sure that you have screened the following typical locations in 2 planes:

- (1) just below the diaphragm where the oesophagus passes through,
- (2) at the coeliac axis,
- (3) before, behind, beside and between aorta and IVC,
- (4) where the common iliac artery splits into internal and external iliac arteries.

N.B. To confirm the diagnosis of malignant lymph nodes, look for:

- (1) a round shape,
- (2) loss of a brighter area at the hilum of the node,
- (3) a longitudinal diameter >2cm.

(i) Urinary bladder

APPROACH. Apply the transducer in a sagittal orientation below the umbilicus right at the midline. While moving it down, rock the transducer head caudally. The urinary bladder will appear as an anechoic black triangle.

METHOD. If possible, the bladder should be filled to the maximum. If the patient is catheterized, clamp the catheter some time before you plan the examination. With an empty bladder, you will neither be able to evaluate the wall nor detect suspicious intra-luminal lesions.

Scan the urinary bladder completely in longitudinal, sagittal and transverse planes and observe the wall carefully for irregularities.

In chronic cystitis and schistosomiasis, you will find a diffuse wall thickening >5mm, whereas a tumour will present as a more localized swelling. Keep in mind that you might find a thickening of the entire wall due to chronic urinary bladder outlet obstruction too. To differentiate between these, it is useful to calculate the residual post-micturition volume remaining in the bladder. The simplified formula, $\frac{2}{3}(d^1d^2d^3)$, i.e. two-thirds the product of the three greatest diameters, is sufficient for your evaluation. Suspect a bladder outlet obstruction if the calculated volume is >100ml.

(j) Prostate

APPROACH. Apply the transducer in a sagittal orientation below the umbilicus right in the midline and rock the probe caudally while moving it down. In the sagittal as well as in the transversal section you will find the prostate just dorsal to the urinary bladder.

METHOD. Make sure that the urinary bladder is filled to the maximum before performing this examination. This makes it very easy to identify. While scanning the prostate in 2 planes, pay attention to its shape which is not exactly round but should be smooth on the surface. If the prostate is enlarged, it might elevate the floor of the urinary bladder.

To evaluate the enlargement of the prostate, measure the greatest transverse diameter from the transverse section, the greatest supero-inferior diameter from the sagittal section and the greatest antero-posterior diameter from either image plane. Use the simplified volume formula to calculate the volume. It should be ≤ 25 ml.

Keep in mind that the grade of prostatic hypertrophy does not necessarily correlate with the symptoms the patient has. Expect prostate cancer if the prostate has invaded the urinary bladder or destroyed the continuity of the bladder wall. Usually, prostatic cancer appears darker than normal prostatic tissue.

(k) Uterus and ovaries

APPROACH. Ask your patient to have a full bladder for this examination. Apply the transducer in a longitudinal orientation caudal to the umbilicus right along the midline and rock it caudally. Her uterus will appear dorsal to the triangularly shaped urinary bladder. Also scan her uterus in a transversal orientation.

METHOD. The myometrium of the uterus should show a homogeneous pattern with a smooth surface. The brightness and width of the endometrium vary with her menstruation cycle. Right after her menstruation, you will only detect a bright reflex, whereas after ovulation the central reflex has disappeared and the endometrium appears hyperechoic throughout.

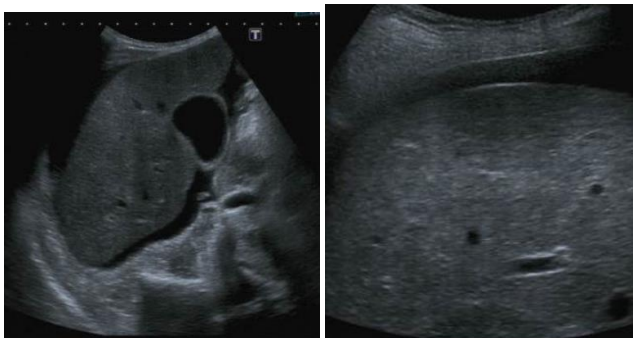
Common but benign findings are fibroids which usually display the same or less brightness as the myometrium. Sometimes fibroids contain calcifications or central necrosis. In these cases, a follow-up is necessary as they sometimes become sarcomas. Measure the size of a fibroid accurately to exclude rapid progression on her next visit and be sure that the fibroid is indeed part of the uterus and not a solid ovarian tumour which is in most cases not benign.

Using transabdominal ultrasound, ovaries will not be easy to find unless they are pathological. The most common findings are ovarian cysts which can grow to respectable size but are harmless. However, rapid growth, solid parts or septations within the cyst might be a sign of teratoma or malignancy and need further examination. An adnexal mass with solid and cystic components is likely to be an ectopic gestation; if it is more solid, it is probably a tumour, and if more cystic, an abscess. Bilateral cystic adnexae often imply endometriosis.

(l) Acute abdominal pain

APPROACH & METHOD. In much abdominal pathology you will find fluid in the abdominal cavity (38-12). Owing to the anatomy of the diaphragm, pelvis and spine, fluid will collect at typical sites: between liver and kidney, between kidney and spleen, dorsal to the urinary bladder.

ULTRASOUND SCAN FOR FREE FLUID



A **B**
Fig. 38-12 Free fluid around the liver, separating it from the diaphragm (A, top left. B, top). *N.B. This amount of fluid is usually from a traumatic haemoperitoneum or ascites, but may be from generalized peritonitis.*

After Atlas of Ultrasound 2023 Erlangen Cookie-Richtlinien-EU.

Place the transducer on the right anterior axillary line as you would do to scan the right kidney. If possible, ask the patient to hold his breath in inspiration. If he is already intubated, ask the anaesthetist to stop ventilation for a moment.

Look for a blackish fringe between liver and kidney. The diaphragm appears superior to the liver as a bright thick curved line. Look for darkness beyond (superior to) it, indicating the presence of a pleural effusion.

Now place the transducer in a sagittal orientation right on the midline caudal of the umbilicus and rock the transducer caudally. You should now find the urinary bladder in its typical triangular configuration. Look for any collection of fluid behind the bladder or, in women, behind the uterus.

You may also find a circumscribed fluid collection anywhere in the abdomen, and even within the liver or spleen; this is likely to be pus.

You should also be able to spot abnormal masses (including an ectopic gestation) and para-aortic and mesenteric lymphadenopathy.

Look specifically for thickened structures, such as the gallbladder and its wall, or the appendix: if this is swollen >6mm, appendicitis is likely *but you should not rely on ultrasound appearances to diagnose appendicitis* (14.1).

(m) Neonatal skull

APPROACH. Have the setting for your young patient well prepared. There should be an infrared light over the examination table and the room should be as quiet as possible. Ask the parent to have the child fed about 1h before and to bring some toys which the baby is interested in. Although you will start the examination with the sector transducer, you will probably wish to switch to the linear transducer in between, in order to use its better near-field resolution.

The neonatal skull offers the unique opportunity to scan the brain, the ventricles and the subarachnoid CSF spaces. The anterior fontanelle serves as your acoustic window until its closure at the age of 18 months. Place the sector transducer in a sagittal orientation on the anterior fontanelle and tilt it slightly laterally.

METHOD. On the laterally tilted sagittal section you will get lots of information at once. At first sight, you will recognize the lateral ventricle as an anechoic curved fringe. Scan consecutively left and right. Attached to the caudal parts of the lateral ventricle you will find brighter areas representing the choroid plexus. The plexus should have a regular bright echogenicity, a smooth outline without any bulging.

Acute intracerebral haemorrhage presents hyperechoic, usually located near the ventricles, which makes it sometimes difficult to distinguish from normal choroid tissue.

Pay careful attention to the contour of the ventricles as CSF filled parenchymal defects near the ventricles might be a clue for an already resorbed intrauterine haemorrhage. Between the 24th and 32nd gestational weeks, the ependymal matrix, which covers the inside of the ventricles, proliferates. During these weeks, the premature neonate is extremely susceptible to intracerebral haemorrhage. But keep in mind that the contour of the ventricle might also change due to an obstructive (internal) hydrocephalus caused by other reasons than intracerebral haemorrhage.

Additionally you just might find little ventricular cysts which are benign as long as they do not impair the CSF circulation. Therefore, if you have found any evidence for alterations at or near the ventricles, you should evaluate the width of the ventricles and the subarachnoid CSF spaces in the coronal plane.

In the mid-coronal plane, you will easily find the connection between the 3rd ventricle and the lateral ventricles across the foramen of Munro: this structure looks like the letter 'Y'. Also in this plane the choroid plexus is displayed as a hyperechoic structure with a smooth outline best seen in the lateral ventricles. In this plane you can measure the width of the 3rd ventricle which should be <10mm in the neonate. If you suspect a non-communicating hydrocephalus, you do not only expect dilated ventricles but also narrowed subarachnoid CSF spaces due to ventricular extension.

If you find widened subarachnoid CSF spaces, you should think of cerebral atrophy instead. To measure the subarachnoid CSF space, it is an advantage to switch to the linear transducer for the best near-field resolution. Apply the transducer on the anterior fontanelle in the mid-coronal plane and determine the cranio-cortical distance which should be <4mm and the inter-hemispheric width which should be <6mm in the neonate.

(n) Bone

Fractures are easy to spot, particularly in ribs (where the bone is almost subcutaneous). This is especially useful anteriorly, where the ribs are cartilaginous and invisible on radiographs.

ULTRASOUND SCAN OF OSTEOMYELITIS

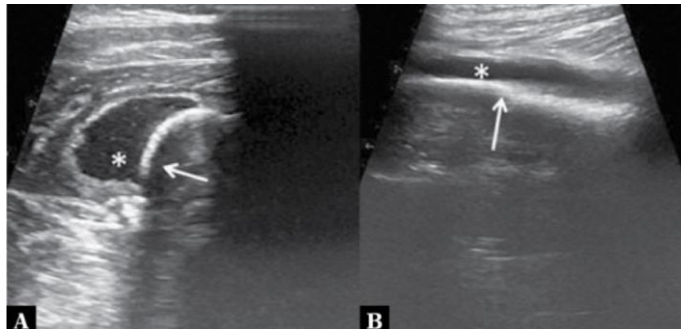


Fig. 38-13 Deep soft tissue fluid collection around bone. A, axial and B, sagittal sections through the distal thigh show deep fluid collection (white star) next to the distal femoral metaphysis (white arrow).
After Paliwal AK, Sahdev RS, Deshwal A, Ram B. Role of ultrasound in the diagnosis of paediatric acute osteomyelitis. *J Ultrason* 2021; 21(84):34-40.

Fluid around bone is also easily spotted, so can pick up a diagnosis of osteomyelitis after 3 days of infection. You can see adjacent increased vascularity also on Doppler.

(o) Separate tips

Confirming diagnosis of cysts:

- (1) Almost round shape
- (2) Sharp demarcation
- (3) Anechoic content
- (4) Posterior acoustic enhancement
- (5) Accentuated entrance/exit echo.

To differentiate between a simple cyst and an abscess:

An abscess: whilst immature, an abscess will show internal echoes and sometimes a brighter rim. When the abscess matures, it will become more and more anechoic and at some point you will not be able to differentiate it from a cyst sonographically. If you can press on the cystic structure and elicit pain, it is more likely to be an abscess, but this is not wholly reliable, especially in patients with HIV-neuropathy.

A dilated vessel: scan the structure in both planes and figure out where it comes from and where it goes to. A vessel will always have some connection to another vessel.

(p) Normal values in adults

Appendix:	maximum size >6mm diameter
Gallbladder:	wall thickness <0.4cm before food maximal size 11x4cm
Common bile duct:	transverse diameter (wall to wall) <8mm (<i>but increases with age</i> <i>0.1mm/yr</i>) <i>N.B. After a cholecystectomy,</i> <i><10mm</i>
Common hepatic duct:	transverse diameter <5mm
Portal vein:	diameter 13-15mm
Aorta:	diameter <3cm
Kidney:	maximal size 12x6 cm cortical width >13mm
Prostate:	normal size 2x2x2cm (young man), growing with age
Urinary bladder:	wall thickness <0.4cm filled volume <750ml post-micturition volume <100ml

38.3 Ultrasound in pregnancy

Ultrasound is easily the most useful and reliable diagnostic tool in pregnancy, and you must learn to use it (38.2).

The gestational sac is visible at 4½wks, the yolk sac at 5wks, and the embryo at 5½wks. You can readily discern the position of the placenta (a thickening on the amniotic sac wall), the heartbeat, and the lie.

Dating the gestational age to check on the size and growth of the foetus is possible at 7-13wks by measuring the crown-rump length, from 13wks measuring the biparietal diameter (BPD, 2.4-9.5cm at term), and from 14wks the femur length (FL, 1.5-7.8cm at term). Also measure the abdominal circumference (AC): this gives a clue to polyhydramnios.

Make an estimate of foetal weight by using the formula:

$$\text{Wt (g)} = 1.4 \times (\text{BPD}) \times (\text{FL}) \times (\text{AC}) - 200 \text{ (cm)}$$

Multiple pregnancy and intra-uterine death are easy diagnoses.

You can readily diagnose certain foetal malformations, *viz.* hydrocephalus, anencephaly, meningomyelocele, exomphalos, gastroschisis, duodenal atresia, cleft lip and palate, and cardiac abnormalities. An expert may detect many more features, however.

If there is a dark collection behind the placenta, this suggests an abruption.

A uterine rupture presents as a collapsed amniotic space and free fluid in the abdomen.

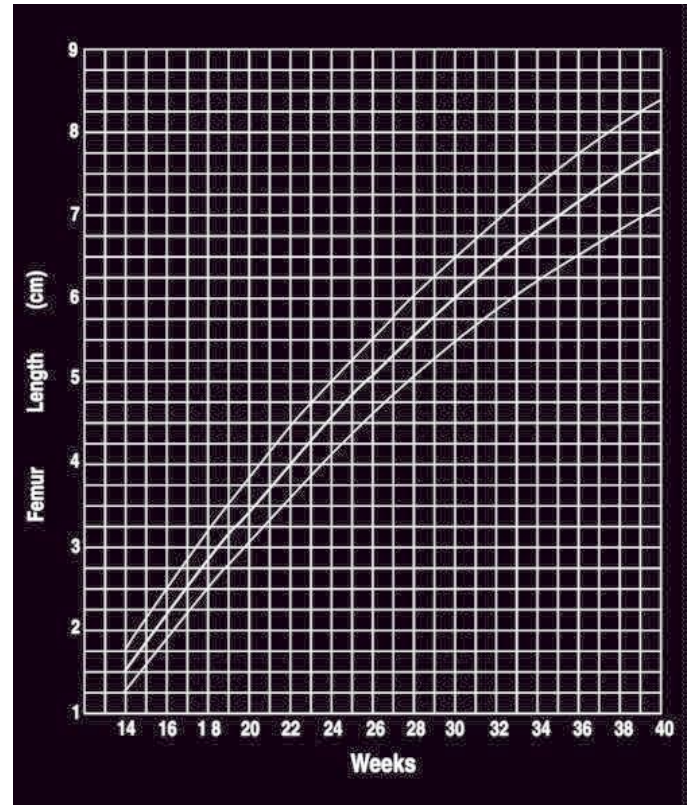


Fig. 38-15 CENTILES OF FOETAL FEMUR LENGTH.

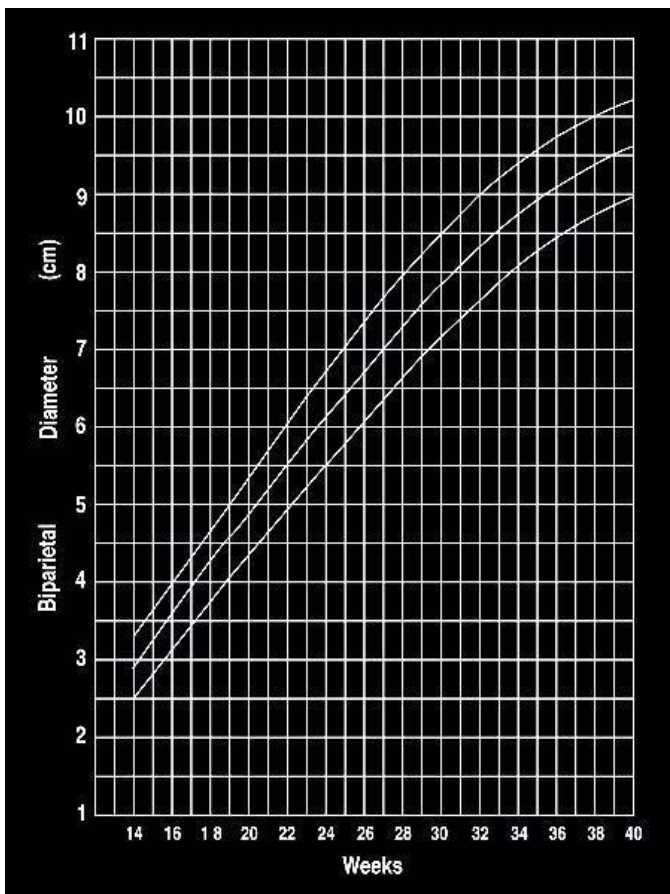


Fig. 38-14 CENTILES OF FOETAL BIPARIETAL DIAMETERS.

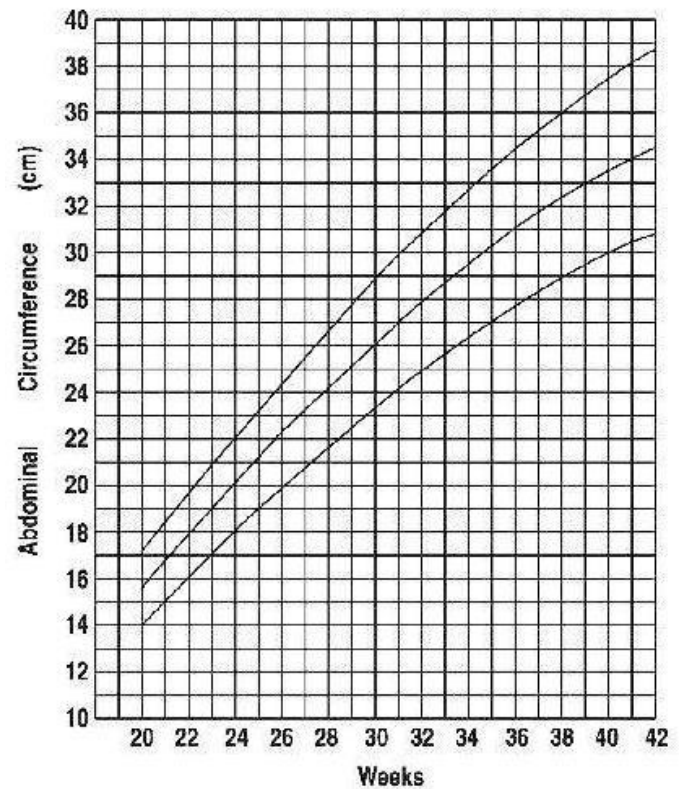


Fig. 38-16 CENTILES OF FOETAL ABDOMINAL CIRCUMFERENCE.